ammoniacal solution of basic copper carbonate, excellent catalysts were also prepared using other techniques. Catalysts prepared by impregnating transitional alumina with an aqueous solution of copper acetate or copper nitrate showed extremely high oxidation efficiencies and a high degree of resistance to the poisoning effects of the oxides of gasoline constituents.

An important feature of the catalysts of this invention is their excellent thermal stability properties. The catalyst bed temperature under normal engine operation may vary from 400 to 1700° F. Under extreme conditions of severe acceleration and deceleration, bed temperatures as high as at least 1750° F. have been observed. Using catalysts of this invention, catalyst beds have been operated at temperatures at least this high without substantially affecting catalytic activity. The property of heat stability is very important because it obviates the necessity of installing a mechanical system to have the exhaust gas bypass the catalyst bed in case of extremely high temperatures. Such a by-pass system would be required if the catalyst were susceptible to damage at high temperatures. Good thermal stability is also desirable in that it allows the reaction to be carried out at higher temperatures wherein higher efficiencies may be attained. Furthermore, this property becomes important when considering the design of a commercial vehicle exhaust system incorporating an oxidation catalyst. The additional heat from the oxidation process would naturally tend to overheat the passenger compartment. This problem could be solved by insulating the catalyst bed and exhaust system. Of course, this would be possible only if the catalyst could tolerate the higher temperatures due to the insulation.

Still another important feature of the catalysts of this invention is their ability to catalyze reactions at extremely low temperatures. Since catalyst activity generally increases with temperature, in many applications it can be optimized by the simple expediency of increasing reaction temperatures. However, in exhaust gas conversion, temperatures cannot readily be controlled and a rather anomalous requisite of high activity at both low and high temperatures is imposed. The catalysts of this invention are active at a temperature as low as 350° F., i.e., temperatures below that of the exhaust gas stream. However, catalyst activity is markedly improved at temperatures of 400° F. and above. Activities at lower temperatures may be obtained when the catalyst is promoted with a second metal. Of course, as the oxidation starts, the heat of reaction serves to raise bed temperatures to a much higher level.

Catalysts of this invention have been tested under actual operating conditions in modern automobiles with excellent results; namely, substantial oxidation of hydrocarbons and carbon monoxide, a discharge exhaust gas substantially free of noxious odors, activity at both high and low temperatures and under a wide variety of operation conditions, resistance to poisons in the exhaust stream. Our catalysts are particularly resistant to poisoning by sulfur compounds commonly found in gasolines. This is an important consideration for current commercial gasolines may contain up to 0.10 percent sulfur, and it could entail a significant expenditure to remove such compounds.

The fuels used during these tests contained a variety of modern fuel additives and the catalysts were remarkably resistant to poisoning from these varied sources. The vehicle tests, conducted under typical urban and country driving conditions, provided an opportunity to investigate the effects of physical and thermal shock on the catalyst material. These tests revealed that in spite of the many shocks and continual agitation, the resistance to attrition of the catalysts of this invention is such that special mechanical contrivances are not required to safeguard the catalyst material. The catalyst is simply put into a suitable container with openings to receive and discharge the exhaust gases. To firmly retain the catalyst material, the receiving and discharge openings are covered with wire screening. The container may have internal baffeling to allow greatest contact between catalyst and exhaust gas, and/or to use the hot reaction gases to heat the incoming exhaust gases. The container may actually replace the vehicle muffler, or it may be incorporated into the conventional exhaust system of current vehicles. The catalyst bed may also be located in the exhaust manifold or in the tailpipe of the exhaust system.

To aid the oxidation, secondary air may or may not be introduced into the system. To obtain maximum efficiency, we have found it preferable to introduce secondary air into the system. This is accomplished by the use of a variable speed blower, so that the amount of secondary air varies with operation conditions. The secondary air supply may also be introduced as a natural flow through the use of an appropriate air scoop, ventura, or the like.

Our catalysts can be used to convert the exhaust gas of any gasoline. The gasolines can be of the aliphatic, aromatic and olefin type including both straight run and catalytically produced gasolines and any and all mixtures thereof. The gasolines can contain the usual additives including organolead and other antiknock agents, such as tetraethyllead, tetraphenyllead, tetramethyllead, mixtures of alkylleads, such as tetraethyllead-tetramethyllead mixtures, ferrocene, methylcyclopentadienyl magnanese tricarbonyl, cyclopentadienyl nickel nitrosyl, scavengers, antioxidants, such as aromatic amines and diamines, 2,6-dialkyl- and 2,4,6-trialkyl phenols, dyes, deposit modifiers, including trimethyl phosphate, dimethylphenyl phosphate, and the like.

In addition to use in spark ignition internal combustion engines, the present catalyst may also be used to reduce or eliminate unburned hydrocarbons and carbon monoxide from the exhaust products of combustion processes in general. This includes the compression ignition engine, oil and coal furnaces, residual fuel burners, etc.

We claim:

1. The method of substantially oxidizing the hydrocarbon and carbon monoxide constituents of the exhaust gas of internal combustion engines which comprises contacting said exhaust gas together with oxygen with a catalyst composition consisting essentially of a transitional alumina support containing from 0.01 to about 5 weight percent silica and, as a catalytic agent, copper oxide in an amount such that said composition contains from about 0.5 to about 25 weight percent copper and from about 0.5 to about 10 weight percent of at least one promoter metal selected from the group consisting of silver, cobalt, and the combination of cobalt and vanadium, said cobalt and vanadium being in an oxide form.

2. The method of claim 1 wherein said catalytic agent is copper oxide in an amount such that said composition contains from about 0.5 to about 25 weight percent copper and from about 0.5 to about 10 weight percent of silver as a promoter metal.

3. The method of claim 1 wherein said catalytic agent is copper oxide in an amount such that said composition contains from about 0.5 to about 25 weight percent copper and from about 0.5 to about 10 weight percent of cobalt as a promoter metal.

4. The method of claim 1 wherein said catalytic agent is copper oxide in an amount such that said composition contains from about 0.5 to about 25 weight percent copper and from about 0.5 to about 10 weight percent of cobalt and vanadium as a promoter metal.

5. A catalyst composition consisting essentially of a transitional alumina support containing from 0.01 to about 5 weight percent silica and, as a catalytic agent, copper oxide in an amount such that said composition contains from about 0.5 to about 25 weight percent copper and from about 0.5 to about 10 weight percent of at least one promoter metal selected from the group consisting of silver, cobalt, and the combination of cobalt and